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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 09/389,491
Filing Date: September 03, 1999
Appellant(s): LEE ET AL.

Eugene M. Lee
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed February 23, 2004.

(1) Real Party in Interest

A statement identifying the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

A statement identifying the related appeals and interferences which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the brief.

(3) Status of Claims

The statement of the status of the claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Invention

The summary of invention contained in the brief is correct.

(6) Issues

The appellant's statement of the issues in the brief is correct.

(7) Grouping of Claims

Appellant's brief includes a statement that claims 12,14 – 24, and 26 do not stand or fall together and provides reasons as set forth in 37 CFR 1.192(c)(7) and (c)(8).

(8) Claims Appealed

The copy of the appealed claims contained in the Appendix to the brief is correct.

(9) Prior Art of Record

6,166,423 Gambino et al. 12-2000

5,534,461	Kuwajima	7-1996
6,074,907	Oh et al.	6-2000
6,066,555	Nulty et al.	5-2000

(10) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 12, 14 – 16, 18 – 22, 24 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gambino et al. (USPAT 6166423, Gambino) in view of Kuwajima (USPAT 5534461).

Gambino discloses a method of making a semiconductor integrated circuit capacitor in figures 11 – 26.

With regard to claim 12, Gambino discloses in figure 11 providing an insulating substrate (305). Gambino discloses in figure 11 simultaneously forming a first wire line (315) and a lower electrode (310) on predetermined surfaces of the insulating surfaces. Gambino discloses in figure 11 forming an interlevel insulating layer (307) on the substrate, on the first wire line, and on the lower electrode. Gambino discloses in figure 12 selectively etching the interlevel insulating layer to expose a predetermined surface of the lower electrode and a predetermined surface of the first wire line thereby simultaneously forming in the interlevel insulating layer: (i) a first via hole (320) having sidewalls and disposed above the lower electrode; and (ii) a second

via hole (330) disposed above the first wire line. Gambino discloses in figure 13 forming a tungsten containing conductive layer (328) on the interlevel insulating layer and in the first and second via holes, including on the exposed predetermined surfaces of the lower electrode and first wire line. Gambino discloses in figure 14 performing a tungsten etch back process to selectively etch back the tungsten containing conductive layer on the interlevel insulating layer and in the first and second via holes to form: ii) a tungsten containing conductive plug from the tungsten containing conductive layer formed in the second via hole on the predetermined surface of the first wire line from the tungsten containing conductive layer formed in the second via hole, and iii) an exposed surface containing the conductive plug, the predetermined surface of the lower electrode, and predetermined surfaces of the interlevel insulating layer. Gambino does not disclose etching back the conductive layer to form a spacer on the sidewalls of the first via hole. Kuwajima teaches in figures 1 – 4, 10 and 18, the abstract and column 7, lines 50 – 62 performing a tungsten etch back process to selectively etch back a tungsten containing conductive layer (14 in figures 1 – 4 and 10; 44 in figure 18) on an interlevel insulating layer (12 in figures 1 – 4 and 10; 42 in figure 18) and in the first and second via holes (15c and 15b, respectively in figures 1 – 4 and 10; 45b and 45a, respectively in figure 18) to form: i) a tungsten containing conductive sidewall spacer on sidewalls of the first via hole and a portion of an exposed predetermined surface of a lower electrode (13b left of center in via 15c in figures 1 – 4 and 10; 41b in figure 18) from the tungsten containing conductive layer formed in the first via hole; ii) a tungsten containing conductive plug in the second via hole on the predetermined surface of a first wire line (13b above right most region 8 in figures 1 – 4 and 10; 44b in figure 18) from the tungsten containing conductive layer formed in the second via hole, the tungsten

containing conductive sidewall spacer and the tungsten containing conductive plug being formed of the same tungsten containing conductive layer; and iii) an exposed surface containing the spacer, conductive plug, a portion of the predetermined surface of the lower electrode not covered by the tungsten containing conductive sidewall spacer, and predetermined surfaces of the interlevel insulating layer (see figure 10). It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the tungsten etch back process of Kuwajima in the method of Gambino in order to form wiring layers having a good burying state, a good coverage state and a planarized surface to maintain good step coverage as stated by Kuwajima in the abstract and column 1, lines 13 – 15. This motivation also applies to other via structures besides wires. It should be noted that using the tungsten etchbeck process of Kuwajima in the method of Gambino would also serve the intended use for preventing dielectric disconnection. Further, intended use recitations do not define patentable subject matter in a device claim when the references would serve the same function. In this case, the combination would necessarily serve the function for preventing dielectric disconnection even though a different reason for combination is established. Gambino discloses in figure 15 forming a dielectric layer (322 on the exposed surface, and the tungsten containing conductive layer formed in the first via hole. It would have been further obvious in the method of Gambino and Kuwajima that the dielectric layer would be formed tungsten containing conductive sidewall spacer. Gambino discloses in figure 16 removing the dielectric layer on the exposed surface except for a predetermined portion of the dielectric layer disposed on the first via hole and predetermined surface of the lower electrode. It is further obvious in the method of Gambino and Kuwajima that the removing would include removing the dielectric layer on the exposed surface except for a predetermined

portion of the dielectric layer disposed on the tungsten containing conductive sidewall spacer. Gambino discloses in figure 18 simultaneously forming: (i) a second wire line (left most 324) connected to the tungsten containing conductive plug; and (ii) an upper electrode connected to the dielectric layer.

With regard to claim 14, Gambino discloses in column 5, line 33 that the dielectric layer has a structure a single-level structure containing an oxide layer.

With regard to claim 15, Gambino discloses in column 8, lines 7 –11 the oxide layer is made using a deposition technique employing Plasma Enhanced Oxide (PEOX). It is inherent that PECVD as described in line 17 is the same as PEOX when depositing oxide.

With regard to claim 16, Gambino discloses in column 6, lines 13 – 17 the nitride layer is made using a deposition technique employing Plasma Enhanced Nitride (PESiN). It is inherent that PECVD as described in line 17 is the same as PESiN when depositing nitride.

With regard to claim 18, Gambino discloses in column 5, lines 31 – 45 the lower and upper electrodes are made of aluminum. It is inherent that aluminum used in the processing of silicon wafers is an alloy of aluminum and silicon.

With regard to claim 19, Gambino discloses in column 5, lines 37 – 39 an anti-reflection layer is disposed on the lower and/or upper electrode's surface.

With regard to claim 20, Gambino discloses I column 5, lines 37 – 39 wherein the anti-reflection layer has a single level structure comprised of Ti.

With regard to claim 21, Gambino discloses in column 5, lines 37 – 39 a barrier layer is disposed on the lower and/or upper electrode's surface.

With regard to claim 22, Gambino discloses in column 5, lines 37 – 39 wherein the barrier layer has a single level structure comprised of Ti.

With regard to claim 24, Gambino discloses in column 7, lines 39 – 48 the interlevel insulating layer is selectively etched by the process of dry etching. Reactive ion etching, as disclosed in column 7, line 48 is a dry etching process.

With regard to claim 26, Kuwajima teaches in figures 1 – 4, 10 and 18, the abstract and column 7, lines 50 – 62 that the spacer formed on the sidewalls of the via hole has a sloping surface.

Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gambino and Kuwajima as applied to claims 12 and 14 above, and further in view of Oh et al. (USPAT 6074907, Oh).

It is not clear if Gambino and Kuwajima teach that the dielectric layer has a multi-level structure containing layers selected from the group consisting of oxide layers, nitride layers, and mixtures thereof. Oh teaches in column 4, lines 49 – 51 a dielectric layer that has a multi-level structure consisting of oxide/nitride/oxide layer (ONO). It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the ONO layer of Oh in the process of Gambino and Kuwajima in order to form a high capacitance capacitor dielectric material.

Claim 23 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gambino and Kuwajima as applied to claim 12 above, and further in view of Nulty et al. (USPAT 6066,555, Nulty).

It is not clear if Gambino and Kuwajima teach further comprising, after forming the first and second via holes, RF sputter etching the interlevel insulating layer and the first and second via holes. Nulty teaches in column 2, lines 56 – 60 RF sputter etching an interlevel insulating layer and via holes. It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the RF sputter etching of Nulty in the process of Gambino and Kuwajima in order to remove native oxide on top of the conducting layers as stated by Nulty in column 2, lines 56 – 60.

(11) Response to Argument

1. Claims 12, 14 – 16, 18 – 22, 24 and 26 are properly rejected under U.S.C. § 103(a)

A. The Gambino Reference

With regard to applicant's assertion that Gambino teaches "in FIG. 14, the third conductor 328 is entirely removed from inside the first opening 320," it should be noted that while the figures are a representation of the invention, they do not necessarily represent the entire intent of the disclosed invention. In this case, while the figures show that the conductor is removed from the inside of the first opening, i.e. there is no visible conductor 328 remaining in the first opening 320, Gambino teaches in column 7, line 60 – column 8, line 2 wherein "third conductor 328 is then partially removed." [Emphasis added]. Further, Gambino refers to Ha et al. (J.H. Ha et al., "Reduction of Loading Effect by Tungsten Etchback in a Magnetically Enhanced Reactive Ion Etcher," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 9 (2), 289 – 291 (1996), attached in appendix A hereto) in order to describe a preferred embodiment of this etchback process. A review of Ha clearly shows that the intent of Gambino's etchback step is to

remove the tungsten 328 from the top surface of the dielectric 307, and further supports the notion that Gambino does not expressly disclose "entirely" removing the conductor 328 from the first opening 320, as asserted by the applicant. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "Gambino et al. reference addresses neither a problem of dielectric disconnection as described in the subject application nor a problem of step coverage in the first opening 320," it should be noted that the problem of dielectric disconnection is an intended use and/or functional language recitation that bears no patentable weight in regard the claimed process of making and the lack of any "problem of step coverage" is not a claimed feature. Dielectric disconnection is a problem that results when conventional steps are used to form a MIM capacitor in the prior art as taught by the appellant in the current written specification, and in the appeal brief on pages 2 – 3. Appellant has successfully proven in the appeal brief section entitled "SUMMARY OF INVENTION" that the claimed process steps prevent dielectric disconnection. It would follow that a combination of references, such as Gambino and Kuwajima, who obviously teach all of the claimed process steps would necessarily also prevent dielectric disconnection. There is no requirement in U.S.C 103 that either reference teach the intended use and/or functional language of dielectric disconnection. Further, Gambino's silence to dielectric disconnection is neither an indication that there is no dielectric disconnection in Gambino's disclosed invention, nor is it an indication that dielectric disconnection is not prevented by Gambino's disclosed invention. Thus, Gambino need not singularly address dielectric disconnection directly in order for the combination, as presented in

the rejection, to have the intentional use and/or function of preventing dielectric disconnection. Therefore, appellant's arguments are not persuasive and the rejection is proper.

A. The Kuwajima Reference

With regard to applicant's argument that the "Kuwajima reference does not teach, mention or suggest the problem of dielectric disconnection that is addressed by the claims of the present invention, and is in fact directed to an entirely different problem, namely that of obtaining a planarized wiring layer in a device having contact holes of different diameters, and therefore differing aspect ratios," it should be noted that the problem of dielectric disconnection is an intended use and/or functional language recitation that bears no patentable weight in regard the claimed process of making. Dielectric disconnection is a problem that results when conventional steps are used to form a MIM capacitor in the prior art as taught by the appellant in the current written specification, and in the appeal brief on pages 2 – 3. Appellant has successfully proven in the appeal brief section entitled "SUMMARY OF INVENTION" that the claimed process steps prevent dielectric disconnection. It would follow that a combination of references, such as Gambino and Kuwajima, who obviously teach all of the claimed process steps would necessarily also prevent dielectric disconnection. There is no requirement in U.S.C 103 that either reference teach the intended use and/or functional language of preventing dielectric disconnection. Kuwajima's silence to dielectric disconnection is neither an indication that there is no dielectric disconnection in Kuwajima's disclosed invention, nor is it an indication that dielectric disconnection is not prevented by Kuwajima's disclosed invention. Also, Kuwajima's solution to the problem of planarization in wiring layers in a device having contact

holes of different dimensions does not bear any effect on the issue of dielectric disconnection as it singularly relates to the claimed invention. Thus, Kuwajima need not singularly address dielectric disconnection directly in order for the combination, as presented in the rejection, to have the intentional use and/or function of preventing dielectric disconnection. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellants assertion that in Kuwajima "tungsten 14c remaining in the contact hole is formed entirely on the barrier metal layers 13a and 13b, and not on the insulting material of the sidewalls of the contact hole," it should be noted that in using the tungsten etchback step of Kuwajima in the method of Gambino the tungsten remaining in the contact hole would be formed on the insulating material of the sidewalls of the contact hole. Further, the claimed invention does not specify that the sidewall spacers be on the insulating materials of the sidewalls of the contact hole. One cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). Therefore, appellant's assertions are not persuasive and the rejection is proper.

With regard to appellant's argument that Kuwajima "does not teach formation of any electrode, including a lower electrode for a capacitor," it should be noted that Gambino is relied upon for this feature in the rejection. One cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. However, in figure 18 of Kuwajima, which was relied upon in the combination of the final rejection, clearly shows an electrode 41b. Also, an electrode is well known to those of ordinary skill in the art as any conductor that is used to establish electrical contact. Kuwajima's "electrode" clearly reads on

what one of ordinary skill would recognize as an electrode. The descriptor "lower" when used in describing this electrode is merely intended use and/or functional language that does not add any unintended results to the functionality of Kuwajima's electrode. Likewise, the lower electrode being a lower electrode of a capacitor is an intentional use and or functional language recitation that bears no patentable weight in this method of making claim. The fact that Kuwajima's lower electrode is not the lower electrode of a capacitor does not bear any functional relationship to the etchback process step that Kuwajima is used for in the combination with Gambino. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "the assertion made by the Examiner that the tungsten etch back process and structures resulting therefrom are 'for preventing dielectric disconnection' in the Kuwajima reference is inherently flawed, as there is no dielectric in the contact holes of the Kuwajima reference in which dielectric disconnection could occur, making the prevention thereof a moot point," it should be noted that that using the tungsten etchback process of Kuwajima in the method of Gambino would also serve the intended use and/or functional language "for preventing dielectric disconnection". Further, intended use and/or functional language recitations do not define patentable subject matter in a device claim when the references would serve that function. In this case, the combination would necessarily serve the intended use or function "for preventing dielectric disconnection" even though a different reason for combination is established. For clarity, this section of the rejection has been amended as not to assert that Kuwajima directly teaches "for preventing dielectric disconnection". Examiner maintains that the combination of references does server the intentional use and/or

functional language "for preventing dielectric disconnection", and thus reads on the claimed invention. Therefore, Appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that the "purpose, function, result and manner of use of the tungsten sidewall spacers according to the Kuwajima reference is completely different from the purpose, function, result and manner of use of the sidewall spacers of the present invention that addresses the problems of possibly incurring dielectric disconnection in a dielectric layer that is deposited on an electrode in a via hole, which problem is not possible in the Kuwajima reference," [emphasis added] it should be noted that "purpose, function, result and manner of use" are not patentable features in a method of making claim when the method of performing the step or steps is the same as the claimed invention and necessarily has the same "purpose, function, result and manner of use" when the references are taken in combination. For instance "purpose, function, result and manner of use" all define intended use and/or functional language that are not patentable features in a method of making claim when the method of the references clearly would have the same intended use and/or function. In this case, the method in which Kuwajima performs the etchback step, when used in combination with Gambino, would have the same "purpose, function, result and manner of use" as the claimed invention. One cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. In a claim drawn to a process of making, the intended use must result in a manipulative difference as compared to the prior art. See *In re Casey*, 152 USPQ 235 (CCPA 1967) and *In re Otto*, 136 USPQ 458, 459 (CCPA 1963). Therefore, Appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "the Examiner insists on mischaracterizing the teachings of the prior art by simply asserting that the mere presence of tungsten sidewall spacers in the Kuwajima reference is sufficient teaching and suggestion to use the sidewall spacers in the present invention," it should be noted that it is not the "mere presence of tungsten sidewall spacers in the Kuwajima reference" that provides "sufficient teaching and suggestion to use the sidewall spacers in the present invention". Appellant's interpretation of the combination is clearly "mischaracterizing" the rejection. As seen in the rejection, above, and in the final office action, it "would have been obvious to one of ordinary skill in the art at the time of the present invention to use the tungsten etch back process" [emphasis added], not the sidewalls themselves, "of Kuwajima in the method of Gambino". Also, the final rejection clearly states that the suggestion to combine Kuwajima with Gambino is "in order to form wiring layers having a good burying state, a good coverage state and a planarized surface to maintain good step coverage as stated by Kuwajima in the abstract and column 1, lines 13 – 15." Appellant does not state why these reasons for the combination fail. Therefore, Appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that this "assertion is tantamount to saying that the mere teaching of a sidewall spacer in a reference for a particular purpose or function precludes the patentability of an entirely different method, which also utilizes a sidewall spacer albeit for an entirely different purpose," [emphasis added] it should be noted that "a particular purpose or function" does not define patentable features in a method of making claim when the method step or steps of the prior art are the same as the claimed invention and necessarily have the same " particular purpose or function". For instance "a particular purpose or function" both define

intended use and/or functional language that are not patentable features in a method of making claim when the method of the references clearly would have the same intended use and/or function. In this case, the method in which Kuwajima performs the etchback step, when used in combination with Gambino, would have the same "particular purpose or function" as the claimed invention. One cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. In a claim drawn to a process of making, the intended use must result in a manipulative difference as compared to the prior art. Therefore, Appellant's arguments are not persuasive and the rejection is proper.

C. The Prior Art References are properly combined

With regard to appellant's argument that it "is not enough that one may modify a reference in view of a second reference, but rather it is required that the second reference suggest the modification of the first reference and not merely provide the capability of modifying the first reference," it should be noted that current interpretations of U.S.C 103 do not support this argument. MPEP 2143.01 states "Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge of one of ordinary skill in the art." In this case a suggestion for a modification, or motivation, can be found in the final office action, repeated above, as "in order to form wiring layers having a good burying state, a good coverage state and a planarized surface to maintain good step coverage as stated by Kuwajima in the abstract and column 1, lines 13 –

15." Appellant has not stated why these motivations fail. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "the complete lack of a dielectric layer in which to incur a dielectric disconnection in contact holes of the Kuwajima reference, and the lack of reference to a dielectric disconnection problem or a step coverage problem in the first opening of the Gambino et al. reference, Applicants have repeatedly submitted that there is no motivation to combine the tungsten sidewall spacers taught in the Kuwajima reference with the device of the Gambino et al. reference, and that any combination thereof to reject the claims of the subject application is improper and based on impermissible hindsight construction," it should be noted that the intended use and/or functional language limitation of "dielectric disconnection" and the "no motivation" issue have been addressed above, and for simplicity will not be repeated here. In response to applicant's argument that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. But so long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. See *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971). It should be noted that it is the etchback process that results in the dielectric spacers, not the dielectric spacers per se, of Kuwajima that are combined with the method of Gambino, not the device of Gambino. Further, because Kuwajima teaches that the sidewall spacer 14c improves the step coverage of the wiring layer, it would follow that when the sidewall spacer is used in the method of Gambino the step coverage of the device in the trench

with the sidewall spacer would be improved. In this case the "wiring layer" with improved step coverage would be a capacitor with improved step coverage in the combination. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that it "is well-settled law that for a claimed invention to be rejected on grounds of obviousness, the prior art must suggest the modifications sought to be patented," it should be noted that, as stated in the final office action and repeated above, "Kuwajima teaches in figures 1 – 4, 10 and 18, the abstract and column 7, lines 50 – 62" the modifications sought to be patented. Appellant has not suggested why this section of Kuwajima fails to teach the claimed etch back process. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "there is not suggestion or motivation for the proposed combinations of the art relied upon by the Examiner. Accordingly, any combination of the art without such evidence is an improper hindsight reconstruction using applicant's invention as a template," it should be noted that, as stated in the final office action and repeated above, the motivation of "in order to form wiring layers having a good burying state, a good coverage state and a planarized surface to maintain good step coverage as stated by Kuwajima in the abstract and column 1, lines 13 – 15" has been provided. Appellant has not stated why these motivations fail. In response to applicant's argument that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. But so long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's

disclosure, such a reconstruction is proper. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to applicant's argument that "it is respectfully submitted that the Examiner's repeated assertion that 'the tungsten sidewall spacer is intended to be used to prevent dielectric disconnection' is necessarily based on improper hindsight reconstruction," it should be noted that the prevention of dielectric disconnection is an intended use recitation and or function of the claimed invention and is met by the combination of Gambino and Kuwajima. It is not necessary for Kuwajima to meet this limitation when taken alone. As argued above the combination of Gambino with Kuwajima would necessarily have the feature of preventing dielectric disconnection. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "the tungsten sidewall spacer of the Kuwajima reference is formed on a barrier metal layer and a metal wiring layer is formed on the tungsten sidewall spacer. There is no dielectric layer formed on the tungsten sidewall spacer of the Kuwajima reference. Accordingly, there is absolutely no possibility of dielectric disconnection in the Kuwajima reference," it should be noted that there is no requirement in U.S.C 103 that either reference teach an intended use recitation explicitly. Kuwajima's silence to dielectric disconnection is neither an indication that there is no dielectric disconnection in Kuwajima's disclosed invention, nor is it an indication that dielectric disconnection is not somehow prevented by Kuwajima's disclosed invention. Thus, Kuwajima need not singularly, nor in combination with any other reference, address dielectric disconnection directly in order to prevent dielectric disconnection. In this case, the combination of Gambino with Kuwajima would have the intended use property of preventing dielectric disconnection. Kuwajima is used to teach an

etchback process. One cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. When using the etchback process of Kuwajima in the method of Gambino the intended use recitation of preventing dielectric disconnection would be met. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "the tungsten sidewall spacer cannot be intended to be used to prevent dielectric disconnection as asserted by the Examiner, and in fact, the Kuwajima reference itself teaches that the sidewall spacer 14c, which is formed on the barrier metal layer 13b, and not on the insulating material 12 in which the contact hole is formed is for improving the step coverage of a wiring layer," it should be noted that the above arguments regarding the intended use recitation of dielectric disconnection apply and will not be repeated here. Further, because Kuwajima teaches that the sidewall spacer 14c improves the step coverage of the wiring layer, it would follow that when the sidewall spacer is used in the method of Gambino the step coverage of the device in the trench with the sidewall spacer would be improved. In this case the "wiring layer" with improved step coverage would be a capacitor with improved step coverage in the combination. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's assertion that "the barrier metal layer 13b of Kuwajima" is not an electrode, it should be noted that Kuwajima as a whole is used as a reference. Figure 18 of Kuwajima is specifically referred to in the final rejection, repeated above, wherein an electrode 41b is depicted. Appellant has not argued why this electrode does not read on the bottom electrode of the invention. Further, one of ordinary skill would recognize that the barrier layer

13b could also be used for a lower electrode. For example, an electrode is well known to those of ordinary skill in the art as any conductor that is used to establish electrical contact. Kuwajima's barrier layer clearly reads on what one of ordinary skill would recognize as an electrode. The barrier layer being a lower electrode of a capacitor is an intentional use and or functional language recitation that bears no patentable weight in this method of making claim. The fact that Kuwajima's lower barrier layer is not functionally an electrode of a capacitor does not bear any functional relationship to the etchback process step that Kuwajima is used for in the combination with Gambino. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument "the Examiner is taking structural features of the prior art that appear visually similar to those of the subject application out of the context of the prior art reference, thereby divorcing from the structure the function or purpose of that structure as taught by that reference, and then mentally attaching to the structure a new and completely different function or purpose as taught by the subject application, which is not taught in the prior art, and using such teaching to reconstruct the claims of the present invention just to reach the rejection thereof," [emphasis added] it should be noted that the "structural features" of the prior art that the appellant refers to are actually method steps of etching back taught by Kuwajima. As recited above the "function or purpose" of claimed method steps clearly indicate that the appellant is arguing intended use and/or functional language in the claimed invention. Intended use and/or functional language does not constitute patentable subject matter in a method of making claim when the method of the references clearly would have the same intended use and/or function. In this case, the method in which Kuwajima performs the etchback step, when

used in combination with Gambino, would have the same "function or purpose" as the claimed invention. One cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. In a claim drawn to a process of making, the intended use must result in a manipulative difference as compared to the prior art. Therefore, Appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "the Examiner took the tapered tungsten sidewall spacer 14c out of the context of the Kuwajima reference, in which its purpose is to improve the step coverage of the contact hole and in which it is formed on the barrier metal layer 13b only and not on the insulating material of the sidewalls of the contact hole, and applied to the tapered tungsten sidewall spacer 14c functions taught in the subject application, which are not taught in the prior art references, and which are precluded in the Kuwajima reference by the very nature of the Kuwajima reference, to reverse engineer the claims of the subject application," it should be noted that appellant is mischaracterizing the rejection. The rejection takes the etch back process of Kuwajima, which results in the formation of sidewall spacers, and applies it as the etchback process in Gambino in order to form wiring layers (or other layers embedded in trenches) having a good burying state, a good coverage state and a planarized surface to maintain good step coverage as stated by Kuwajima in the abstract and column 1, lines 13 – 15. Appellant has not stated why these motivations fail. Further, the combination of Gambino and Kuwajima would necessarily have the intended use and/or function that are claimed as discussed above. Thus, no "reverse engineering" has been done, and only the process step of etching back, which one of ordinary skill in the art would obviously use from Kuwajima in the method of Gambino,

is used in the rejection. Therefore, appellant's arguments are not persuasive and the rejection is proper.

With regard to appellant's argument that "it is respectfully submitted that based on the teachings of the cited prior art references, the Examiner's conclusion of obviousness necessarily includes knowledge gleaned only from the applicant's disclosure, and such a reconstruction is in fact improper," it should be noted, with reference to the above responses to the presented arguments, that the rejection is proper. Further, In response to applicant's argument that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. But so long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. Therefore, appellant's arguments are not persuasive and the rejection is proper.

Therefore, appellant's arguments are not persuasive and claims 12, 14 – 16, 18 – 22, 24 and 26 are properly rejected over Gambino in view of Kuwajima. Accordingly it is believed that the rejections should be sustained.

2. Rejection of claim 17 under 35 U.S.C § 103(a)

With regard to appellant's argument that "there is no motivation or basis to combine the teachings of the Gambino et al. reference and the Kuwajima reference to arrive at this rejection other than through impermissible hindsight construction, and that combining the teachings of the Oh reference with those of the Kuwajima reference and the Gambino et al. reference does not

render claim 17 of the subject application obvious, as the combined teachings do not teach all of the limitations of claim 12, from which claim 17 indirectly depends," it should be noted that all of the above arguments apply here, and the no impermissible hindsight construction is made in the Final rejection. All of the features of claim 12 are taught in the combination of Gambino with Kuwajima, as discussed above. Oh teaches all of the features of claim 17 for which it is relied upon in the rejection. Oh is not relied upon to teach features of claim 12. Therefore, appellant's arguments are not persuasive and the rejection is proper.

Accordingly, the rejection of claim 17 is proper and should be sustained.

3. Rejection of claim 23 under 35 U.S.C § 103(a)

With regard to appellant's argument that "there is no motivation or basis to combine the teachings of the Gambino et al. reference and the Kuwajima reference to arrive at this rejection other than through impermissible hindsight construction, and that combining the teachings of the Nulty et al. reference with those of the Gambino et al. reference and/or the Kuwajima reference does not render claim 23 of the subject application obvious, as the combined teachings do not teach all of the limitations of claim 12, from which claim 23 depends," it should be noted that all of the above arguments apply here, and the no impermissible hindsight construction is made in the Final rejection. All of the features of claim 12 are taught in the combination of Gambino with Kuwajima, as discussed above. Nulty teaches all of the features of claim 23 for which it is relied upon in the rejection. Nulty is not relied upon to teach features of claim 12. Therefore, appellant's arguments are not persuasive and the rejection is proper.

Accordingly, the rejection of claim 23 is proper and should be sustained.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

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Appendix A

Reduction of Loading Effect by Tungsten Etchback in a Magnetically Enhanced Reactive Ion Etcher

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Abstract—**The plug loading effect occurring during the etchback of tungsten was investigated in a magnetically enhanced reactive ion etcher using SF_6/Ar mixtures. It was found that while the plug loading effect is independent of varying SF_6/Ar flow rate ratio and magnetic field intensity, it is reduced under the condition of high selectivity of tungsten relative to TiN which was achieved at high chamber pressure and low RF power. It is proposed that when TiN is used as a glue layer, the W etch rate enhancement in the plug is mainly controlled by a local loading effect. Under the optimized etchback conditions the plug loss was successfully controlled without the tungsten residue left on severe topology.**

I. Introduction

As circuit density increases in VLSI technology, filling of high aspect ratio contact holes becomes a problem when aluminum is applied. Chemical vapor deposition (CVD) of tungsten is a good alternative because of its superior step coverage [1]–[3], and also because it can provide a planarized contact. Tungsten plugs are commonly formed by blanket W deposition, followed by a fluorine based etch back [4]–[6]. However, the problem of plug loss observed after tungsten etchback, which results from the so-called loading effect is of paramount importance, because this plug loss reduces the planarity of the contact and worsens the step coverage of subsequent Al interconnect. In this study, a magnetically enhanced reactive ion etcher which provides high etch rates owing to high ion densities [7], [8] was chosen to examine how controlling the etch parameters during etchback can minimize the loading effect. In addition, the relationship of the loading effect with the selectivity of tungsten relative to TiN is described in detail.

II. Experimental

As shown in Fig. 1, the tungsten etch structure used in this study consisted of 0.8 μm of blanket tungsten over a glue layer consisting of 600 Å of reactively sputtered TiN and 300 Å of Ti. The TiN was sputtered on top of the Ti layer. The contact holes were 0.5 μm in diameter defined in 1.0 μm silicon oxide layer. Etchback was accomplished in an Applied Materials P5000 magnetically enhanced reactive ion etch system with SF_6/Ar chemistry. Experiments were performed at an electrode temperature of 35° or 10°C and a constant total flow of 120 sccm. The end point of the tungsten etchback process was monitored by optical emission at 6540 Å resulting from excited N_2 molecules. Etch rates and profiles were monitored by a scanning electron microscope (SEM).

III. Results and Discussion

In order to evaluate the plug loading effect, tungsten was etched in SF_6/Ar mixtures until excited N_2 molecules from the underlying TiN glue layer were detected in the plasma, and an overetch was subsequently performed for a fixed etch time.

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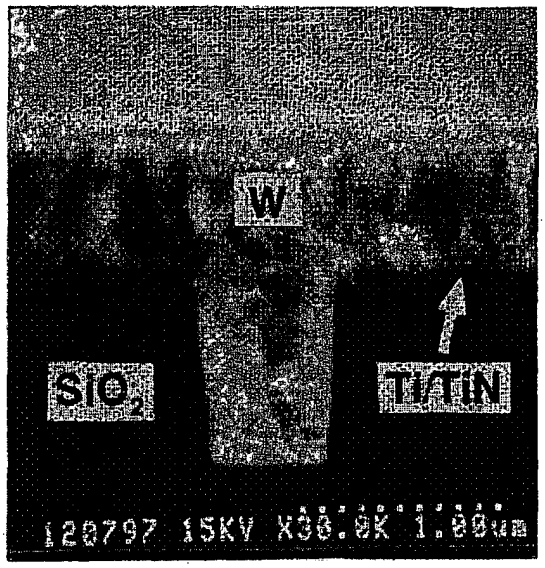

Fig. 1. SEM cross section of tungsten etch structure used in this study.

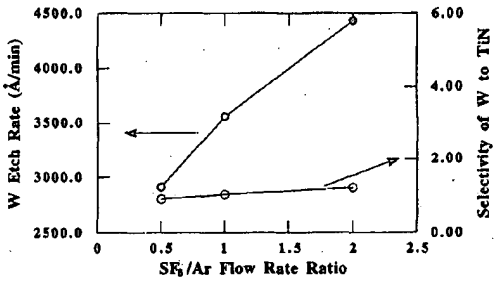

Fig. 2. Etch rate of tungsten and selectivity of tungsten relative to TiN layer as a function of SF_6/Ar flow rate ratio at 85 mT, 475 W, and 20 G.

The plug loading effect, defined below, was monitored under various etch conditions

$$\text{Plug loading effect} = \frac{\text{W etch rate in plug}}{\text{bulk W film etch rate}}$$

where the bulk tungsten etch rate and the tungsten etch rate in the plug were determined by measuring the difference in thickness of blanket W film and the plug loss observed from scanning electron micrograph (SEM) cross sections after a fixed etch time, respectively. In order to investigate the main cause of the plug loading effect, the etchback characteristics of W were studied by varying etch parameters.

Figs. 2–5 show the tungsten etch rates and the selectivity of tungsten relative to TiN layer as functions of SF_6/Ar flow rate ratio, magnetic field intensity, pressure and power. As expected, the tungsten etch is mainly induced by the chemical reaction with fluorine ions forming volatile WF_6 as a product [3], [9], [10]. The tungsten etch rate increased with increasing the concentration of active etching species in the plasma, which results from increasing SF_6/Ar flow rate ratio, magnetic field intensity, power and pressure [11]–[14]. Figs. 2 and 3 indicate that the SF_6/Ar flow rate ratio and magnetic field

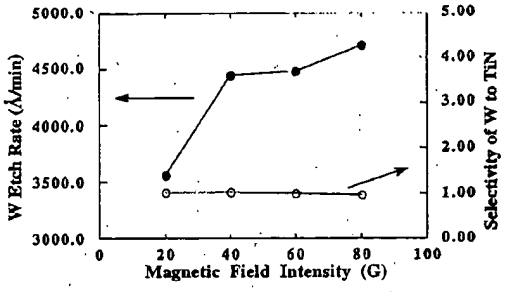

Fig. 3. Etch rate of tungsten and selectivity of tungsten relative to TiN layer as a function of magnetic field intensity under the conditions of 60 sccm SF_6, 60 sccm Ar, 85 mT, and 475 W.

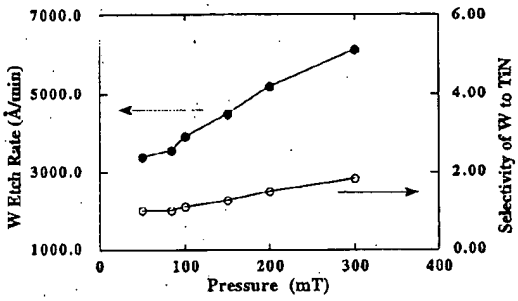

Fig. 4. Etch rate of tungsten and selectivity of tungsten relative to TiN layer as a function of pressure under the conditions of 60 sccm SF_6, 60 sccm Ar, 475 W, and 20 G.

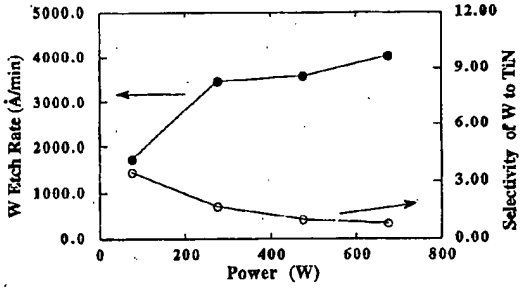

Fig. 5. Etch rate of tungsten and selectivity of tungsten relative to TiN layer as a function of power under the conditions of 60 sccm SF_6, 60 sccm Ar, 85 mT, and 20 G.

intensity do not considerably influence the selectivity of tungsten relative to TiN. However, as shown in Fig. 4, the selectivity of tungsten relative to TiN increased with increasing pressure because while the tungsten etch rates increased with increasing pressure, TiN etch rates slightly decreased with increasing pressure. In addition, the selectivity of tungsten relative to TiN decreased with increasing power because the etch rate of TiN increased more rapidly than that of the tungsten with increasing power (Fig. 5). These results strongly suggest that unlike tungsten, TiN etch is dominantly controlled by the physical effect of ions in SF_6/Ar plasmas which increase rapidly with increasing power and decreasing pressure [9], [11], [15]. The largest increase in the selectivity of W relative to TiN was observed when the electrode temperature was lowered to 10°C (Fig. 6). However, at 10°C, considerable residue was observed on the TiN surface [16], [17]. This residue, which is believed to be composed of a layer of fluorinated TiN, frequently inhibited further etching, so that an extra wet cleaning step was needed for removal [16], [17]. Therefore,

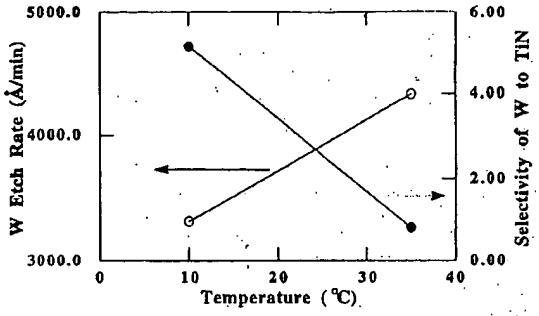

Fig. 6. Etch rate of tungsten and selectivity of tungsten relative to TiN layer at an electrode temperature of 10 and 35°C under the conditions of 60 sccm SF_6, 60 sccm Ar, 85 mT, 475 W, and 20 G.

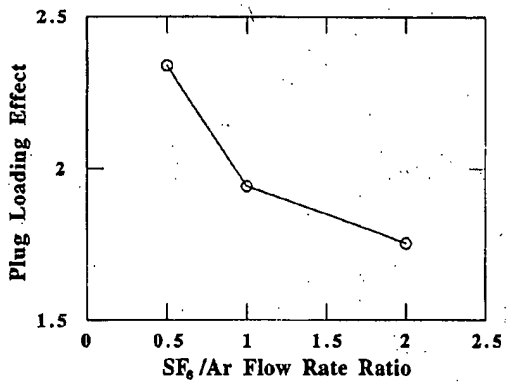

Fig. 7. Plug loading effect as a function of SF_6/Ar flow rate ratio at 85 mT, 475 W, and 20 G.

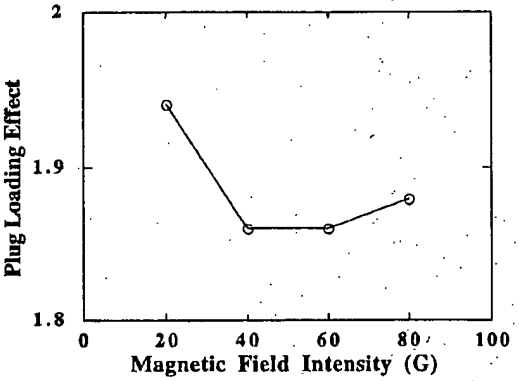

Fig. 8. Plug loading effect as a function of magnetic field intensity under the conditions of 60 sccm SF_6, 60 sccm Ar, 85 mT, and 475 W.

considering process cleanliness and simplicity, all the experiments for plug loading effect were performed at an electrode temperature of 35°C.

As presented in Figs. 7 and 8, the plug loading effect and the selectivity of W relative to TiN were almost independent of varying SF_6/Ar flow rate ratio and magnetic field intensity. In addition, Figs. 9 and 10 indicate that the plug loading effect decreased with increasing pressure and decreasing power. As mentioned earlier, increasing pressure and lowering power resulted in an increase of W selectivity relative to TiN. Comparing the dependence of the plug loading effect and W selectivity relative to TiN on etch parameters, it was found

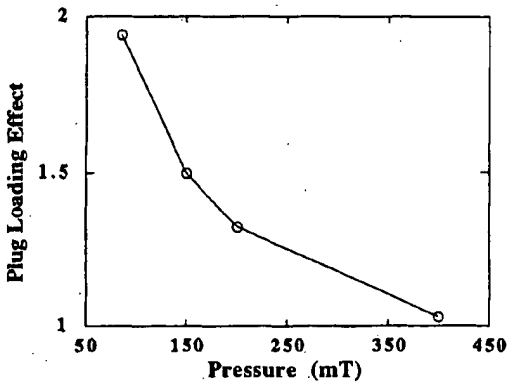

Fig. 9. Plug loading effect as a function of pressure under the conditions of 60 sccm SF_6, 60 sccm Ar, 475 W, and 20 G.

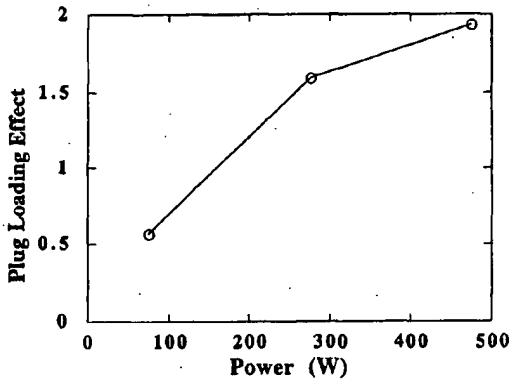

Fig. 10. Plug loading effect as a function of power under the conditions of 60 sccm SF_6, 60 sccm Ar, 85 mT, and 20.

that the plug loading effect can be minimized by achieving high selectivity of W relative to TiN, which was obtained at low power and high chamber pressure. In accordance with previous observations [12], [14], [15], two types of loading effects occur during W etchback: one is a global loading effect, the other is a local loading effect. When the underlying TiN surface is exposed after a bulk W etch, since the total area of W to be etched becomes much smaller and the TiN etch rate is much lower than that of W, some extra fluorine becomes available for etching small amounts of W in the plug, resulting in the increase of plug W etch rate compared to that of bulk W. As a result of this global loading effect, the plug loading effect is expected to increase as the W selectivity relative to TiN increases. However, this expectation is opposite to our experimental results, implying that the global loading effect is not a major mechanism which causes higher W plug etch rate than that of bulk W.

According to the local loading effect, when the TiN surface is reached, nitrogen is liberated, which effectively enhances the dissociation of SFx into reactive fluorine. This increase in F concentration around the contact hole greatly enhances the tungsten plug etch rate [12], [14], [15]. As a result of this local loading effect, the plug W loss becomes serious at low selectivity of W relative to TiN due to the high nitrogen generation rate around the contact holes, which agrees well with our experimental results described earlier. Therefore, during the W etchback with a TiN glue layer, the W etch rate enhancement in the plug is thought to be mainly controlled by the local loading effect. Fig. 11(a) and (b) show the plug profiles after etchback which was performed under the optimized process conditions, where a residual

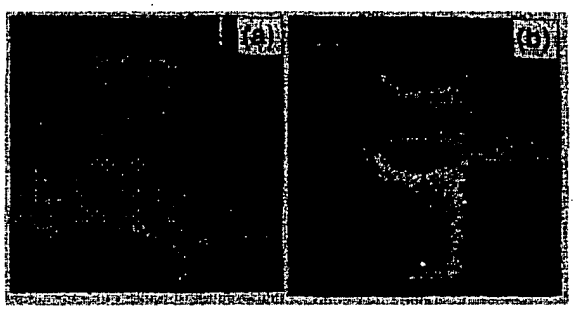

Fig. 11. SEM photographs of (a) tungsten plugs on the topology of 1 μm high and an angle of 30° and (b) an enlarged plug profile for the observation of plug loss.

tungsten on severe topology at an angle of 30° degree was completely removed without a noticeable plug loss.

IV. Conclusion

A tungsten etchback process was characterized for a magnetically enhanced reactive ion etch system using SF_6/Ar mixtures. The influence of etch parameters on the plug loading effect and selectivity of tungsten relative to TiN was evaluated. It was found that the plug loading effect is independent of varying SF_6/Ar flow rate ratio and magnetic field intensity and can be minimized under the condition of the high selectivity of tungsten to TiN, which was achieved at high pressure and low power. The dependence of the plug W etch rate enhancement on the selectivity of tungsten relative to TiN was explained by the local loading effect. As a result of this local loading effect, at high selectivity of tungsten relative to TiN, the liberation of nitrogen is greatly reduced during the exposure of underlying TiN layer, so that hardly any extra F becomes available for etching W in the contact hole, resulting in a negligible loading effect. Under the optimized etchback condition, the residual tungsten on severe topology could be completely removed without a noticeable plug loss.

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